ED 334 988 IR 015 151

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TITLE Chaos, Communication, and Educational Technology.
PUB DATE 91
NOTE 17p.; In: Proceedings of Selected Research Presentations at the Annual Convention of the Association for Educational Communications and Technology; see IR 015 132. Bibliography may not reproduce well because of small type size.
PUB TYPE Information Analyses (070) -- Viewpoints (Opinion/Position Papers, Essays, etc.) (120) -- Speeches/Conference Papers (150)

EDRS PRICE MF01/PC01 Plus Postage.
DESCRIPTORS *Communication (Thought Transfer); Communication Research; *Educational Technology; Research Methodology; *Systems Analysis; *Systems Approach
IDENTIFIERS *Chaos

ABSTRACT

Chaos offers educational communications and technology new systems' tools and ideas; i.e., it provides the system with a deterministic "I don't know" state within which new activity patterns can be generated. Previous characterizations and paradigms of systems stated that simple systems behaved in simple ways, complex behaviors implied complex causes, and different systems behaved differently. These ideas are now undergoing serious and exciting evaluation and re-examination because of chaos. This shift is producing new ways of studying problems, e.g., simple systems give rise to complex behavior and involved descriptions; complex systems may be studied by looking at simple behaviors and simpler systems; and much complexity holds universally, unrelated to the type of system or its components. Summarizing the exploding transformations based on systems and chaos, Linstone (19[illegible]) writes that now these are: (1) new ways to study complex systems; (2) techniques to study problems using multiple perspectives; and (3) approaches to employ "what if" rather than prediction as a basis for planning. Other researchers assert that systems are undergoing a radical change toward the multiple, the temporal, and the complex. Chaos is a toolbox of ideas (and statistical methods) that can aid communicators by providing them with new insights, multiple perspectives, and "what if. . .?" attitudes. (76 references) (BBM)

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are available (Ackoff, 1971; Ashmos and Huber, 1987; Boulding, 1956; Gharajedaghi and Ackoff, 1984). I will not discuss information or information theory. Dervin's theory of information as construction (1989) fits into the current cognitive perspective of communication and her work is excellent. Shaw (1981, 1984) furnishes an overview of information in dynamic systems. Hayles (1990) reviews Shannon's work (1949) and produces an interesting discussion on probability and information. I would recommend that curious readers pursue these references.

The Background: Chaos

Hayles (1990) suggests two ways to view chaos. The first is based on Prigogine and Stengers (1984) and focuses on order out of chaos. Problems develop and can be solved through the "spontaneous emergence of self-organization." The second, and perhaps more highly popularized view (Gleick, 1987), discusses order within chaos. Systems generate new information, the "deeply encoded structures" of strange attractors. While I will refer to the Prigogine and Stengers chaos, most of this paper will be of the "order within chaos" type. Implications will be drawn from both views. The following fourteen points are a brief background to understanding chaos.

1. Predictability relates to simplicity and regularity in systems theory, and, for some researchers, is a "measure of rationality" (Curtis, 1990). Unpredictability is associated with complexity and irregularity. During the past two decades, new ways to study complexity have emerged from many disciplines, such as physics, astronomy, and biology. These methods have grown into a field of study and methodology labeled chaos theory. Chaos "offers a way to understand complicated behaviors as something that is purposeful and structured instead of extrinsic and accidental" (Pool, 1989a, p. 245).

2. Mechanistic models suggest internal regularity, and cause and effect that is understandable and logical (Gharajedaghi and Ackoff, 1984). When cause and effect relationships are unclear, the involved components are described as random elements (Crutchfield, et al., 1986). Given enough data, researchers typically thought, predictability was possible. Now, it has been discovered that "simple determinististic systems with only a few elements can generate random behavior" (p. 46). This randomness, found to be fundamental to the system, is described as "chaos." Deterministic chaos, writes Mandelbrot (1990), shows that although simple systems may obey deterministic laws, their behavior is unpredictable.

3. "In principle, the future is completely determined by the past, but in practice small uncertainties are amplified, so that even though the behavior is predictable in the short term, it is unpredictable in the long term" (Crutchfield, et al., 1986, p. 46). Because initial systems conditions are often impossible to fully and accurately survey, chaos occurs (J. May, 1989).

4. This is due partly to quantum mechanics, which suggests that there is always a randomness (Heppenheimer, 1989) and uncertainty, especially in initial measurements (Crutchfield, et al., 1986). Chaos seems to multiply these uncertainties, resulting in a lack of good prediction ability. Because of the fundamental nature and scope of probability and randomness, those notions are thought to be a unifying principle (Chaitin, 1990). Chaos extends this principle universally.

5. Some of the background for chaos lies in dynamical systems. "A dynamical system is a system whose evolution from some initial state (which we know) can be

Chaos, Communication, and Educational Technology

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Introduction

"Chaos: Making of a New Science" was a best selling book. In it, Gleick (1987) offered the general public a glimpse of the scientific concept chaos. His illustrative overview proved very popular. Following closely came PBS programming from NOVA and Discover. Earlier, in 1984, Prigogine and Stengers wrote what was also to become a best selling book, "Order Out of Chaos." The Nobel Prize winner Prigogine integrated many scientific concepts with literature and nature to present "man's (sic) new dialogue with nature."

Why the interest in chaos? Surely the concern about scientific illiteracy is one reason. However, Gordon and Greenspan (1988) suggest another reason of more interest to communicators. "Chaos is the study of disorder that arises in nonlinear systems and should be of interest to technological, social and economic forecasters since the systems with which they deal are usually nonlinear and disorderly" (p. 1). The emerging framework (based on chaos and the work of Prigogine and Stengers) is intriguing and provocative. Toffler (1984) writes that "it shifts attention to those aspects of reality that characterize today's accelerated social change: disorder, instability, diversity, disequalibrium, nonlinear relationships (in which small inputs can trigger massive consequences) and temporality -- a heightened sensitivity to the flows of time" (p. xiv-xv).

Within this social change, communication systems evolve into complexity. The models based on those realities become more encompassing and possibly "oppressive" (Hayles, 1990). New means of dealing with complexity, combining perspectives, and asking "what if" questions become necessary.

Chaos gives communicators new data, suggests innovative approaches to old ideas, and reaffirms certain approaches. Both Jonassen (1990) and Winn (1990) recently discussed some implications of chaos for instructional design, and Jonassen described chaos as the "theory of complexity." Others have researched chaos and discussed war (Saperstein, 1984), information flow (Shaw, 1981, 1984), computational systems (Huberman, 1989), animal systems (Gould, 1986), computing (May, 1989), and technological and social forecasting (Gordon and Greenspan, 1988). Several papers use chaos to discuss education (Cziko, 1989; Jonassen, 1990; Lehrer, et al., 1990; Winn, 1990). For communication and educational communications and technology, chaos seems to offer some intriguing ways of seeing communication systems. Chaos presents us with new approaches to examining traditional problems, and promises new life to under-used techniques to study communication systems.

In this paper I will present a background on chaos, discuss concepts drawn from the wide-ranging literature of chaos, and list implications chaos could have for communicators. I will not discuss systems theory, an important concern for both communication and chaos. Salisbury (1990) has recently provided a good review of systems concepts for instructional development, and other general systems references

described by a set of rules" (Tsonis and Elsner, 1989). There are two parts of dynamical systems:

> 5.1. the essential data about the system, termed "state." This is often abstract data, which may be "...the degrees of freedom of the system...(Crutchfield, et al, 1986, p. 49). A state may be stable or unstable, and
> 5.2. rules describing how the state evolves with time, termed a "dynamic." Time may be either continuous time (flow) or discrete time (mapping). (Crutchfield, et al., 1986).

Stewart (1989) writes that "...chaos is a dynamic phenomenon. It occurs when the state of a system changes with time" (p. 24). Mathematics has four ways to characterize behavior as a function of time: steady states, oscillations, chaos, and noise (Glass and Mackey, 1988). However, Dunbar (1990) says that chaos "...indicates more a general category of behavior than a specific kind of movement in a dynamical system" (p. 4).

6. Timepaths generated by dynamical systems are very sensitive to changes in initial conditions. "Robust and reliable models are hard to develop" (Baumol and Benhabib, 1989). Timepaths may be characterized four ways:

> 6.1. oscillatory and stable
> 6.2. oscillatory and explosive
> 6.3. nonoscillatory and stable
> 6.4. nonoscillatory and explosive

7. Systems have attractors. An attractor "is what the behavior of a system settles down to, or is attracted to... A system can have several attractors. If that is the case, different initial conditions may evolve to different attractors" (Crutchfield, et al., 1986, p. 50). Thus, attractors take two general forms here: a) a single point that is like a steady state -- nothing happens, and b) a closed loop that is periodic, the behavior repeating itself again and again (Stewart, 1989).

Predictable attractors can be simple points. But attractors that repeat upon themselves are chaotic, or strange attractors. This repetition is *ad infinitum*, "a fractal, an object that reveals more detail as it is increasingly magnified" (Crutchfield, et al., 1986, p. 51).

8. Systems that are chaotic provoke an internal randomness, "...on their own, without the need for any external random input" (Crutchfield, et al., 1986, p. 53). This chaotic behavior "resembles randomness" (Savit, 1990, p. 49).

9. In predictable systems, future conditions or behaviors can be projected from beginning benchmarks. There is cause and effect. Such systems are not overly malleable to errors in the initial stages. However, chaotic attractors change or displace the initial data and put in new data. Small scale uncertainties become larger. "After a brief time interval, the uncertainly specified by the initial measurement covers the entire attractor and all predictive power is lost; there is simply no causal connection between past and future" (Crutchfield, et al., 1986, p. 53)

10. The "average rate" at which data is produced by a system determines its level of chaos. (Crutchfield, et al., 1986).

11. Chaos is grounded in mathematics (Pool, 1989a), particularly in non-linear formulations (May, 1976). The mathematics of chaos allows researchers to define

randomness triggered by simple deterministic dynamical systems (Tsonis and Elsner, 1989). Simply, chaos gives scientists, and now educators, the ability to see patterns in processes once considered totally random.

Glass and Mackey (1988) refer to noise as "chance fluctuations, a randomness that is completely unpredictable, except in a statistical sense" (p. 37). They differentiate noise from chaos, which is a randomness or irregularity in a deterministic system and can be found and identified in the complete absence of noise.

12. There are many definitions of chaos. In his book, Gleick (1987) provided over six definitions for chaos from the research literature. Each writer presents another definition. For communicators, Pool's (1986a) definition may be useful:

> "...deterministic randomness...a type of randomness that appears in certain physical and biological systems and is intrinsic to the system rather than caused by outside noise or interference" (Pool, 1989a, p. 25).

13. May (1976) discusses chaos from a systems perspective: "...the very simplest nonlinear difference equations can possess an extraordinarily rich spectrum of dynamical behavior, from stable points, through cascades of stable cycles, to a regime in which the behavior (although fully deterministic) is in many respects 'chaotic', or indistinguishable from the sample function of a random process" (p. 459).

14. Summarizing the literature of chaos, Gleick (1987) points out that simple systems give rise to complex behavior, and complex systems often can be explained by simple behaviors and rules.

Concepts in Chaos

Several principles and attributes of chaos are of interest to educational communications and technology. These include **sensitive dependence on initial conditions, nonlinearity, and complexity which includes fractals, bifurcations, and strange attractors.**

1. Sensitive dependence on initial conditions: Initial states are the beginning conditions in a system. The system has a "sensitive dependence" on these initial conditions. Pool (1989b,c) notes that if the initial configuration of a system is changed, no matter to what degree, its future behaviors can be altered radically. Uncertainty, the product of a quantum mechanics framework, means that initial conditions are always somewhat unstable or unknown. In chaotic environments, long-term systems solutions may be inherently unpredictable (Pool, 1989a; Pool, 1990b).

Dependence on initial conditions is not a new or alien idea. In communication situations, initial conditions include the problem or source description, audience identification and analysis, and first impressions in an encounter.

2. Nonlinearity: When the system's end product is proportionally equated to the input, over the total input range, the system is linear (Puccia and Levin, 1985). There is a correspondence between cause and effect. Proportionality results in straight lines. Small changes in causes lead to small changes in effects. In nonlinear systems, "the parameters of the system do not vary proportionally" (McRobie and Thompson, 1990).

Nonlinear systems may not proceed step by step and may not have simple dynamical properties. Nonlinear differential equations are used to describe the state. There are unanticipated events; erratic systems behavior is proven to have noting to do with outside input. Cause and effect are not corresponding. Small changes in initial conditions can lead to large changes in effects.

With nonlinearity, changes are not necessarily ordered or orderly. Prediction is questionable. Uncertainty is prevalent. Examples of nonlinearity would include the entire process of message design and delivery.

3. Systems that are chaotic have complex forms: This means those systems include **fractals, bifurcations, and strange attractors.**

3.1. Fractals: "Fractals are geometrical shapes that...are not regular at all. First, they are irregular all over. Second, they have the same degree of irregularity on all scales. A fractal object looks the same when examined from far away or nearby--it is self-similar. As you approach it, however, you find that small pieces of the whole, which seemed from a distance to be formless blobs, become well-defined objects whose shape is roughly that of the previously examined whole" (Mandelbrot, 1990, p. 39).

Systems' components may be self-similar and recursive. They may involve a scaling structure with patterns inside of patterns. While the details of the system are random, the fractal dimension is constant, no matter how complex or holistically viewed. That means that fractals have a "complete structure on any scale of magnification" (Stewart, 1989, p. 46). Fractals may be a "way of seeing infinity" (Gleick, 1987, p. 98). Hayles (1990) calls this approach a "shift in focus" (p. 13) from individual units to levels and systems perspectives. An example of fractals would be the difference in looking at details versus the patterns in systems.

3.2. Bifurcation point: A system undergoes bifurcation, a splitting and diverging of paths that cause system change, when the number and/or stability of a steady state and cycle change (Glass and Mackey, 1988). Bifurcations are real changes in qualitative dynamics, and can start a fractal process (Gordon and Greenspan, 1988), leading to chaos. In fact, Glass and Mackey (1988) write that "period-doubling bifurcations followed by irregular dynamics is taken as evidence that the irregular dynamics are chaotic" (p. 49).

Bifurcations in human systems can be seen in Flach's work (1988) on the life cycle and periods of stress. Stress on stable systems produces a disruption, a bifurcation, and the system changes, often unexpectedly and unpredictably.

3.3. Strange Attractors: Systems' disorder is channeled into patterns with common underlying themes. These "themes" attract or pull the normal energy flow; they are basins of attraction. Strange attractors enlarge the role of attractors; they excite and lure a system's vitality into non-projected patterns. Strange attractors create unpredictability and introduce data into the system. Strange attractors originate from varying initial conditions. Because of their own behavior they change "what we can know about them" (Hayles, 1990, p. 159). Examples would be the student question that throws the class discussion into a new direction, unseen but internal to the system.

Implications

Suggestions from chaos for social systems are beginning to emerge. Nevertheless, there are implications for the fields of communications and educational communications and technology. I will make the following observations:

Observation 1. In our daily activities, seemingly, humans and our organizations pass through processes similar to systems on their way to chaos. [A new idea, criticality (Bak and Chen, 1991; Peterson, 1989) may be important here. Criticality states that systems evolve to critical points, then often unknown and/or unplanned behaviors occur to set them in different directions.] Flach (1988), a psychiatrist, has a life cycle model that provides a parallel motif to chaos theory (Figure 1). He first notes that there are times in life when major shifts must occur. These shift points are bifurcations. Stress occurs to our resting system and we become severely destablized. Our own internal and or external structures may become chaotic. Such bifurcation points happen unexpectedly, as when very traumatic events take place, and expectedly, as when we pass through phases of our lives.

When our steady state systems are stressed, "disruption" takes place. Disruption will be filled with human and organizational turbulence. A chaotic state can follow wherein attractors may help "reintegration"--putting the disrupted parts together into a new homeostases. We self-organize into something unlike we were before. During the chaos, people and organizations cannot necessarily determine or choose future direction. Thus risk is present (Figure 2).

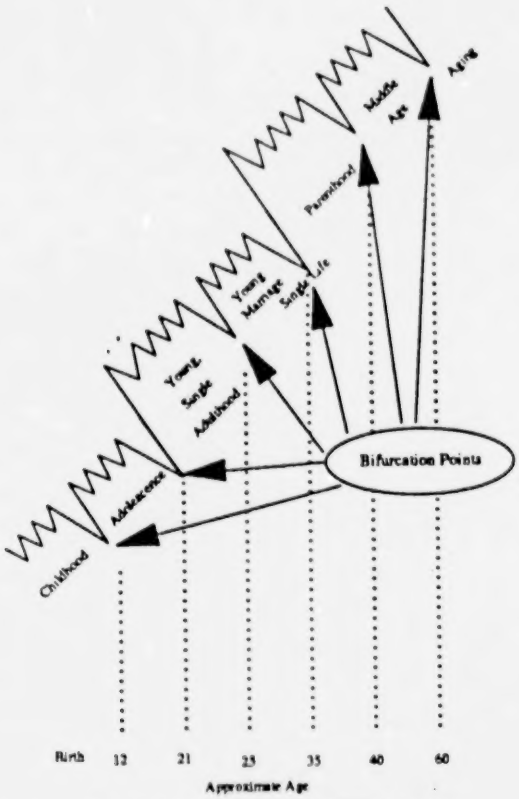


Figure 1: Life Cycle Stages (Flach, 1988)

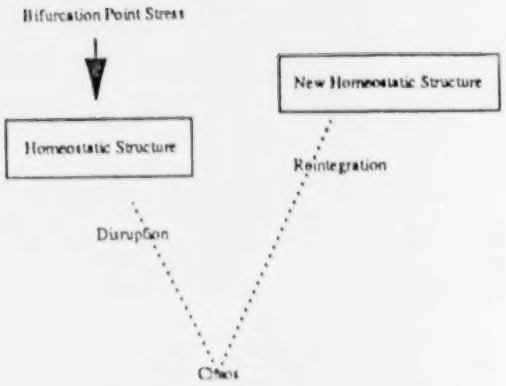


Figure 2: The Normal Disruption-Reintegration Cycle (after Flach, 1988)

Flach (1988) also states that individuals may develop a negative homeostases as a future state. Figure 3 shows a failure to enter a disruptive state. Organizations, and I would add, ideas, can be seen to exhibit similar behavior under stress. A second type of negative outcome is shown below in Figure 4 (Flach, 1988). While disruptive behaviors occur, the system does enter an entropic phase where a dysfunctional outcome emerges.

Figure 3: The Failure to Disrupt (based on Flach, 1988)

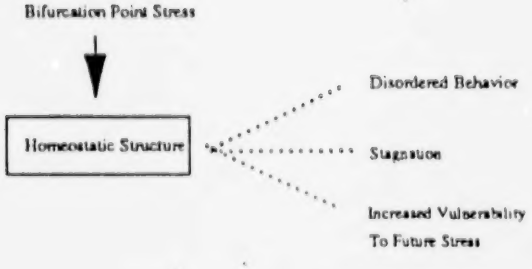
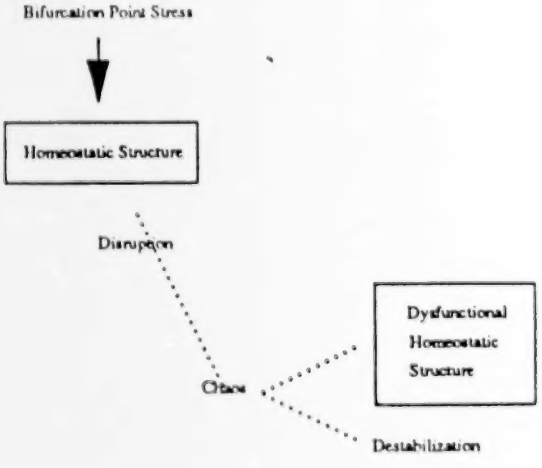


Figure 4: The Failure to Reintegrate Successfully (after Flach, 1988)



An older model (Figure 5, Wheeler, et al. 1986) tried to visualize this idea. How each individual or organization responds to change depends on how change is perceived and also on the type of change occurring. Some changes are easy to accept and adapt to. Four types of change are:

a. Wanted/Expected: If we know something is going to occur and we want it, then the adjustment required is minimal. These types of changes include going to a meeting, the generation of a new idea, teaching, or buying new books.

b. Not wanted/Expected: If we know something is going to happen, but we do not want it to occur, the adjustment required is more taxing. An example of this might be our own physical changes as we age. We cannot avoid them and we usually do not want them to occur, but we cannot do anything about them. Other examples include paying Association dues, buying a full fare airplane ticket, or facing the death of a close teacher or mentor.

c. Wanted/Non Expected: Another type of change is one that we do not expect, but we are happy when it occurs. Such changes can still be stressful, but once the initial surprises and problems are resolved, adjusting to these changes is another pleasant assignment. Examples are unexpected visuals from colleagues, professors, or former students, receiving a promotion, or being invited to present at a large conference for a large fee.

d. Not Wanted/Not Expected: The last category of change is the most difficult to manage because we do not expect it and it is not desirable. Examples might include not getting tenure or promotion, total rejection of an article, or a break-in at the office.

	Wanted	Not Wanted
Expected	*Wanted Expected*	*Not Wanted Expected*
Not Expected	*Wanted Not Expected*	*Not Wanted Not Expected*

Figure 5: Four Types of Change

The implications here are: a) In people and human systems, bifurcation points can be both expected and unexpected, wanted and not wanted; b) The outcomes of these bifurcations are dependent on both initial conditions and attractors; c) Outcomes may be positive, when a new system emerges, or negative, where the current system falters, dysfunctions, regresses, or destablizes; d) The outcomes are relative. That is, depending on the position and values of the individual or system, outcomes may be seen to be positive or negative.

We should be aware of communication systems that are obstructionistic and debilitating (Figure 6: Flach, 1988). Such environments do not support positive systems and should be considered when implementing large scale instructional development projects. While not a series of guidelines, Figure 5 can serve as a checklist of design heuristics.

Figure 6. Debilitating Environmental Structures

Too Rigidly Organized	*Too Much Disarray*
Abusive or demanding	Indulgent
Excessive expectations	Murkey expectations
Stubborn resistance to change	Excessively fluid
Rejecting/ambivalent	Overly permissive
Discourages Communications	Indiscreet
Intolerant of conflict	Perpetuates turmoil
Punitive or vindictive	Excess forbearance
Thwarts hope	Pollyannaish
Rejects new ideas	Rejects tradition
Destructive values	Ill-defined values or none

Source: Flach, 1988, p. 216

In addition, Flach (1988) identified environmental elements that help develop new, positive systems. These are shown in Figure 7:

Figure 7: Elements for a positive environment

- coherent but flexible structures
- a human network
- respectfulness
- recognition
- assurance of privacy
- tolerance of change
- acceptance
- defined, realistic limits on behavior
- open communications
- responsiveness to new ideas
- tolerance of conflict
- promotion or reconciliation
- hopefulness
- a sense of community
- constructive human values
- empathy

(Flach, 1988, p. 213)

There is a simplicity and obviousness in Flach's work, which I believe assists communicators in examining and developing systems.

Observation 2. To examine certain complex ideas and systems, we may have to use and apply simpler systems (Pool, 1990b; Stewart, 1989). That means reviewing some of our more complicated and elaborate communication models and processes to identify their basic features. In these simpler systems, and in the simplicity of basic models, we may find answers to our communication and educational questions.

More complex things evolve from simpler things. But when complexity confuses issues and one needs a "whack on the side of the head," examining and studying simple systems may be helpful. Perceived complexity may mask obvious explanations. While not simplifying problems, simple models may "...yield extremely complex developments" (Baumol and Benhabib, 1989, p. 80). Stewart (1989) summarizes this point when he writes that ".. apparently patternless behavior (sic) may become simple and comprehensible if you look at the right picture" (p. 47).

There is a major implication for our communication and educational technology curriculums (Francis and King, 1990). We need more process type learning activities. Formulas and facts, spoon fed, will not help anyone in the learning environments. Critical thinking, problem solving, creativity, and communication skills can, should, and must be part of each lesson and course. Books like *Drawing on the Right Side of the Brain* (Edwards, 1989, 2nd edition), *Exercises in Visual Thinking* (Wileman, 1980), *experiences in visual thinking* (sic) (McKim, 1972), *Use Both Sides of Your Brain* (Buzan, 1976), *The Art of Creative Thinking* (Nierenberg, 1982), *The All New Universal Travel* (Koberg and Bag, 1981, Rev. ed.), *Conceptual Blockbusting* (Adams, 1976), as well as others, must become part of the communication and educational technology curriculum.

Crutchfield, et al. (1986) write, "Even the process of intellectual progress relies on the injection of new ideas and on new ways to connecting old ideas. Innate creativity may have an underlying chaotic process that selectively amplifies small fluctuations and molds them into macroscopic coherent mental states that are experienced as thoughts. In some cases the thoughts may be decisions, or what are perceived to be the exercise of will. In this light, chaos provides a mechanism that allows for free will within in a world governed by deterministic laws" (p. 57).

Rapp (quoted in McAuliffe, 1990) discusses chaos activity as an asset in problem solving: "You want to be able to scan as wide a range of solutions as possible and avoid locking on to a suboptimal solution early on....One way to do that is to have a certain amount of disorderliness, or turbulence, in your search" (p. 48).

Observation 3. Sensitive dependence on initial conditions questions "whether an effect is proportional to a cause" (Hayles, 1990, p. 16). If initial conditions are known, it would seem that the educational systems evolution may be statistically predicted. Regardless, perfect knowledge of initial conditions is almost impossible. There will always be deviation. Because of the character of attractors, the status of the system at later times may be completely unlike the one planned. This has implications for both classroom and computer management and how teachers, designers, and administrators might approach such management. Dynamics of the instructional process and the interaction among the players are also affected. By more decidedly identifying initial conditions, chaos may be minimized (Curtis, 1990).

For example, chaos can characterize educational settings. Cziko (1989) notes that student achievement may be determined completely by the student's entry skills. The total achievement may be completely unpredictable. Cziko (1989) also points out that tiny knowledge differences between students at the start of instruction may lead to sizable and unpredictable differences between participants by the end of instruction. The lesson for researchers and practioners is that initial conditions have been, are, and will be critical in any educational setting.

Pool (1989a,b) summarizes that by saying that, because of chaos, researchers, at least, will now have an "appreciation" of how little complexity can produce complicated results.

While it is probably impossible to recognize and describe all initial conditions, there are many upfront tools to support communicators. For audience analysis, for example, the Myers-Briggs Temperament Inventory (Barrett, 1989; Barrett and Zamani, 1989; Keirsey and Bates, 1978; Kroeger and Thuesen, 1988; Lawrence, 1982, 2nd ed.) and the Learning Styles Inventory (Kolb, 1976, 1982) are useful instruments, and underexploited by educators. A future tool that may have a part to play in describing initial conditions is fuzzy set theory (Gui and Goering, 1990). This new area of mathematics deals with uncertainty due to lack of sharply defined boundaries. ("Big" is fuzzy; there are not distinctions or clear cut differentiations between "big" and "not big.") Through fuzzy set theory, ambiguous phenomena can be described. Other needed future tools also will include instruments to identify and describe communication sources more quickly, and mechanisms to provide a knowledge of the instructor and the instructor's teaching preference and style to both the instructor and the student.

Observation 4. Nature imposes restraints on planning. Chaos may be confined to areas or events that may be predictable, or at least anticipated in systems. Baumol and Benhabib (1989) note that "...where chaos occurs, extrapolation and estimation ...are questionable." This has implications for the flow of data in organizations. Another restraint is the attractor. What points exist, unplanned and unseen, to attract the system or its component elements?

We have to identify both initial and continuing patterns better. Use of communication case studies (King, 1984), in-class research, and qualitative descriptions (Jonassen, 1990) will have to be better incorporated into research paradigms, better supported by the research community, and better received by professional journals. Expanded use of Masters theses could be one way to carry out the research side.

Observation 5. We will have to recognize intrinsic, non-linear structures (Savit, 1990). However, with nonlinearity and chaos, there is one, degree of order, perhaps temporary, allowing predictability, anticipation, and management. Chaos says that "...apparently random behavior may not be random at all" (Baumol and Benhabib, 1989, p. 80). R. May (1989) wrote that "...we must expect to see chaos as often as we see cycles or steadiness...we would all be better off it more people realized that simple nonlinear systems do not necessarily possess simple dynamical properties" (p. 41).

The issue we face is to find the degree of order necessary to keep the ability, and the flexibility, to adapt, while using the variability inherent in a chaotic situation to advance, rather than continuing to use blinders or wringing our hands about the unfairness of it all (Francis, 1990). We will have to incorporate change in a "world

dominated by interacting processes" (Francis, 1988). Systems analysis of communication systems will be rekindled (Saba, 1989).

Observation 6. We will have to look for scaling structures, examining, comparing, and relating big details to small details. The challenge here is how scale variance affects facts (Hayles, 1990, p. 16). Researchers will have to examine the variability of a system as well as its stable parts (Pool, 1989b,c,d). Individual situations or local systems that are perceived as unpredictable may have stable patterns when viewed from a suprasystems perspective (J. May, 1989). An in-class example might be cooperative learning, moving from the individual, to a group, to groups, to the class, to the entire school. Jonassen (1990) calls it "...seeking the correct scale for examining the learning process..." (p. 33). All organizations can be viewed through a scaling framework.

Observation 7. An issue researchers will have to face is figuring out what to measure. Sources of noise will have to be reviewed (Olsen and Schaffer, 1990). When "noise" is found in a system, and when random behaviors occur, researchers will have to deduce the "attractors" that cause such activity. Distinguishing between chaos and noise will require technical calculations of the data (Pool, 1989a,c,d,e,f) using high level mathematics, powerful computers, and programming, and is both difficult (Meyer, 1991) and "...in its infancy..." (R. May, 1989).

Combining observations 6 and 7, researchers also will need to examine the scale from which to examine. Looking at systems, Paulre (1981) first identifies what to study -- three categories of examination:

a. explanation of an observed changing system,
b. analysis of conditions and effects of change, and
c. forecasting or conjecture of change.

He then discusses scaling, from local, to global, to normal organizational analysis. Paulre developed this mix of scale and components to measure into a 3x3, definition and classification matrix (Figure 8). Such a matrix may offer some researchers a framework for communication analysis, combining scale and content.

	Explanation of an observed changing system	Analysis of conditions and effects of change	Forecasting or Conjecture of change
Local Analysis			
Global Analysis; Phasing & cycles			
Organizational System Structure			

Figure 8: A Framework to define and classify systems (Paulre, 1981)

In examining what to measure, questions are raised about research problems in general. Fuchs and Fuchs (1990) discuss problems with educational research that are reflected in the communication research. These problems include, first, an emphasis on research that is theory driven and lab based rather than program building research, and second, research that is viewed as unimportant, irrelevant, too fractionalized, directionless, and finally, uninterpretable to many. Solutions include in-class communication research as well as participatory research with the teachers and local communication people as team members.

Observation 8. Fractals have an interesting potential for graphic designers (Barnsley, 1988;Barnsley, et al., 1988; Pool, 1989e; Pool, 1990a). The beauty of the fractal patterns seems to have visual power. These images capture attention and command respect. Mandelbrot (1989, 1990) feels that the visual nature of fractals has made them an area of interest. Apparently the mathematics of fractals will soon be used to compress and reconstruct images for digitized visuals.

Conclusions

Chaos offers educational communications and technology new systems' tools and ideas. Chaos provides "the system with a deterministic "I don't know state" within which new activity patterns can be generated.

Previous characterizations and paradigms of systems stated:

1. simple systems behaved in simple ways,
2. complex behaviors implied complex causes, and
3. different systems behaved differently. (Gleick, 1987)

These ideas are now undergoing serious and exciting evaluation and re-examination because of chaos. This shift is producing new ways of studying problems:

1. simple systems give rise to complex behavior and involved descriptions,
2. complex systems may be studied by looking at simple behaviors and simpler systems. (Baumol and Benhabib, 1989; Gleick, 1987), and
3. much complexity holds universally, unrelated to the type of system, or its components.

Summarizing the exploding transformations based on systems and chaos, Linstone (1989) writes that now we have:

1. new ways to study complex systems,
2. techniques to study problems using multiple perspectives, and
3. approaches to employ "...'what if' rather than prediction as a basis for planning" (p. 12).

Prigogine and Stengers (1984) assert that systems are "undergoing a radical change toward the multiple, the temporal, and the complex" (p. xxvii). Chaos is a toolbox of ideas (and statistical methods) that can aid us by providing communicators with new insights, multiple perspectives, and "what if...?" attitudes.

REFERENCES

Ackoff, R. L. 1971. Towards a system of systems concepts. Management Science. 17(11): 661-671.

Adams, J. L. 1978. Conceptual Blockbusting. New York, NY: W. W. Norton.

Ashmos, D. P. and G. P. Huber. 1987. The systems paradigm in organization theory. Academny of Management Review. 12(4): 607-621.

Bak, P. and K. Chen. 1991. Self-organized criticality. Scientific American. 264(1): 46-53.

Barnsley, M. 1988. Fractals Everywhere. San Diego, CA: Academic Press, Inc.

Barnsley, M. F., A. Jacquin, F. Malassenet, L. Reuter, and A. D. Sloan. 1988. Harnessing chaos for image synthesis. ACM Computer Graphics. 22(4): 131-138.

Barrett, L. A. 1989. Impact of teacher personality on classroom environment. J. Psychological Type. 18(Winter): 50-56.

Barrett, L. A. and H. Zamani. 1989. Learning strategies that agricultural students use successfully and unsuccessfully. Paper presented at the National Agricultural Research Meeting. Orlando, FL. December.

Baumol, W. J. and J. Benhabib. 1989. Chaos: significance, mechanism, and economic applications. J. Economic Perspectives. 3(1): 77-105.

Boulding, K. E. 1956. General systems theory--The skeleton of science. Management Science. 2(3): 197-208.

Buzan, T. 1976. Use Both Sides of Your Brain. New York, NY: E. P. Dutton.

Chaitin, G. 1990. A random walk in arithmetic. New Scientist. 25(1709): 44-46.

Crutchfield, J. P., J. D. Farmer, N. H. Packard, and R. S. Shaw. 1986. Chaos. Scientific American. 255(6): 46-57.

Cziko, G. A. 1989. Unpredictability and indeterminism in human behavior: arguments and implications for educational research. Educational Researcher. 18(3): 17-25.

Curtis, R. K. 1990. Complexity & predictability: The application of chaos theory to economic forecasting. Future Research Q. 6(4): 57-70.

Dervin, B. 1989. Users as research inventions. J. Communication. 39(3): 216-232.

Dunbar, S. R. 1990. A tourist guide to chaos and fractals. Presented at the Symposium on Chaos in Biological and Agricultural Systems: Statistical Issues. Lincoln, NE, June 3-5.

Edwards, B. 1989. Drawing on the Right Side of the Brain (2nd ed.). Los Angeles, CA: Tarcher.

Flach, F., M.D. 1988. Resilience: Discovering a New Strength at Times of Stress. New York, NY: Fawcett Columbine.

Francis, C. A. 1988. Unique importance of information in future agricultural production systems. Personal Communication.

Francis, C. and J. King. 1990. Preparing Nebraska students for lifelong learning in agriculture. Crop Production News. 10(25). 2pgs.

Fuchs, D., and L. S. Fuchs. 1990. Making educational research more important. Exceptional Children. 57(2): 102-107.

Gharajedaghi, J., and R. Ackoff. 1984. Mechanisms, organisms and social systems. Strategic Management J. 5: 289-300.

Glass, L., and M. C. Mackey. 1988. From Clocks to Chaos: The Rhythms of Life. Princeton, NJ: Princeton University Press.

Gleick, J. 1987. Chaos: Making a New Science. New York, NY: Viking Penguin, Inc.

Gordon, T. J., and D. Greenspan. 1988. Chaos and fractals: new tools for technological and social forecasting. Technological Forecasting and Social Change. 34: 1-25.

Gui, X. Q., and C. E. Goering. 1990. Introduction to fuzzy set theory and applications. Transactions of the ASAE. 33(1): 306-313.

Hayles, N. K. 1990. Chaos Bound: Orderly Disorder in Contemporary Literature and Science. Ithaca: Cornell University Press.

Heppenheimer, T. A. 1989. Classical mechanics, quantum mechanics, and the arrow of time. MOSAIC. 20(2): 2-11.

Huberman, B. A. 1989. An ecology of machines: how chaos arises in computer networks. The Sciences. 29(4): 38-44.

Jonassen, D. H. 1990. Thinking technology: chaos in instructional design. Educational Technology. 30(2):32-34.

Keirsey D. and M. Bates. 1978. Please Understand Me. Del Mar, CA: Prometheus Nemesis.

King, J. W. 1984. A framework for using case study methodology to describe development communication programs. DevCom Q. 2(3): 1-11.

Koberg, D. and J. Bagnall. 1981. The All New Universal Traveler (rev. ed.). Los Altos, CA: William Kaufmann.

Kolb, D. A. 1976. Learning Style Inventory: Technical Manual. Boston, MA: McBer.

Kolb, D. A. 1982. Personal Learning Guide: Leader Notes. Boston, MA: McBer.

Kroeger, O. and J. M. Thuesen. 1988. Type Talk. New York, NY: Tilden Press.

Lawrence, G. 1986. People Types and Tiger Stripes (2nd ed.). Gainesville, FL: Center for Applications of Psychological Type.

Lehrer, R., R. C. Serlin, and R. Amundson. 1990. Knowledge or certainty? A reply to Cziko. Educational Researcher. 19(6): 16-19.

Mandelbrot, B. 1990. Fractals--a geometry of nature. New Scientist. 127(1734): 38-43.

Mandelbrot, B. B. 1989. Fractals and an art for the sake of science. LEONARDO. Computer Art in Context Supplemental Issue. 21-24.

May, J. H. 1989. Chaos and the marketing of computing services on campus. CAUSE/EFFECT. 12(1):4-6.

May, R. M. 1989. The chaotic rhythms of life. New Scientist. 124(1691): 37-41.

May, R. M. 1976. Simple mathematical models with very complicated dynamics. Nature. 261: 459-467.

McAuliffe, K. 1990. Get smart: controlling chaos. OMNI. 12(5): 42-48, 86-92.

McKim, R. H. 1972. Experiences in Visual Thinking. Montery, CA: Brooks/Cole.

McRobie A., and M. Thompson. 1990. Chaos, catastrophes and engineering. New Scientist. 126(1720): 41-46.

Meyers, G. 1991. Personal Communication.

Nierenberg, G. I. 1982. The Art of Creative Thinking. New York, NY: Cornerstone.

Olsen, L. F., and W. M. Schaffer. 1990. Chaos versus noisy periodicity. Science. 249: 499-504.

Paulre, E. 1981. System Dynamics and Analysis of Change. New York: North-Holland Publishing Company.

Peterson, I. 1989. Digging into sand. Science News. 136(3): 4042.

Pool, R. 1989a. Chaos theory: how big an advance? Science. 245:26-28.

Pool, R. 1989b. Ecologists flirt with chaos. Science. 243:310-313.

Pool, R. 1989c. Is it chaos, or is it just noise? Science. 243:25-28.

Pool, R. 1989d. Is it healthy to be chaotic? Science. 243:604-607.

Pool, R. 1989e. Is something strange about the weather? 243:1290-1293.

Pool, R. 1989f. Quantum chaos: enigma wrapped in a mystery. 243:893-895.

Pool, R. 1990a. Fractal fracas. Science. 249:363-364.

Pool, R. 1990b. Putting chaos to work. Science. 250:626-627.

Prigogine, I. and I. Stengers. 1984. Order Out of Chaos. New York, NY: Bantam.

Puccia, C. J., and R. Levins. 1985. Qualitative Modeling of Complex Systems: An Introduction to Loop Analysis and Time Averaging. Ch. 1. Qualitative Models. p. 1-11. Cambridge, Massachusetts: Harvard University Press.

Saba, F. 1989. Personal Communication.

Salisbury, D. F. 1990. General systems Theory and instructional systems design. Performance and instruction. 29(2): 1-11.

Saperstein, A. M. 1984. Chaos--a model for the outbreak of war. Nature. 309: 303-304.

Savit, R. 1990. Chaos on the trading floor. New Scientist. 127(1729):48-51.

Shannon, C. E., and W. Weaver. 1949. The Mathematical Theory of Communication. Urbana: University of Illinois Press.

Shaw, R. 1984. The Dripping Faucet as a Model Chaotic System. Santa Cruz, CA: Aerial Press, Inc.

Shaw, R. 1981. Strange attractors, chaotic behavior, and information flow. Z. Naturforsch. 36a: 80-112.

Stewart, I. 1989. Portraits of chaos. New Scientist. 124(1689): 42-47.

Toffler, A. 1984. Science and change. In I. Prigogine and A. Stengers. 1984. p. xi-xxvi.

Tsonis, A. A., and J. B. Elsner. 1989. Chaos, strange attractors, and weather. Bulletin American Meteorological Society. 70(1): 14-23.

von Oech, R. 1988. Creative Whack Pack. Stamford, CT: U.S. Games Systems.

Wheeler, D. W., J. W. King, H. G. Lingren, D. W. Swoboda, and J. Randall. 1986. Helping Rural People Under Stress. Lincoln, NE: Nebraska Cooperative Extension Service.

Wileman, R. E. 1980. Exercises in Visual Thinking. New York, NY: Hastings House.

Winn, W. 1990. Some implications of cognitive theory for instructional design. Instructional Science. 19(1): 53-69.

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